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Author(s):	Whicker, Jeffrey Jay Chastenet, Mary Jo Bullock, Christine Anne
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MARSAME Release Report for TA46 Building 1
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Summary

Environmental Protection and Compliance, Environmental Stewardship (EPC-ES) has identified materials associated with technical area 46, Building 1 (TA-46-001) (Figure 1) that meet the criteria for unrestricted release to the public under Department of Energy (DOE) Order 458.1 *Radiation Protection for the Public and the Environment* (DOE 2013). We have also identified materials in certain rooms, e.g., ventilation systems and liquid drains and piping, which do not meet the criteria for unrestricted release and are to be treated as Low Level Waste (LLW). These conclusions are based on the known history of the structures combined with radiation survey data collected in 2018, and findings are consistent with DOE Order 458.1 and Los Alamos National Laboratory (LANL) Functional Series Document EPC-ES-FSD-004, *Environmental Radiation Protection* (LANL 2017). Sampling and data analysis, as described in this report, were sufficient to meet measurement quality objectives under the Multi-Agency Radiation Survey and Assessment of Materials and Equipment (MARSAME) manual (MARSAME 2009) and LANL procedures (LANL 2015). Final approvals for waste disposition will come from LANL's Waste Management Program.

The scope of this final release report includes structure TA-46-001 (Figure 1). Floorplans for building 46-001 are provided in Figures 2 through 4. Metal materials included in this report are not subject to the DOE metal moratorium. While MARSAME provides guidance on statistical sampling for residual radionuclides in bulk materials, smaller miscellaneous items can be released via the release procedures outlined in LANL Policy 121 *Radiation Protection* (LANL 2018)

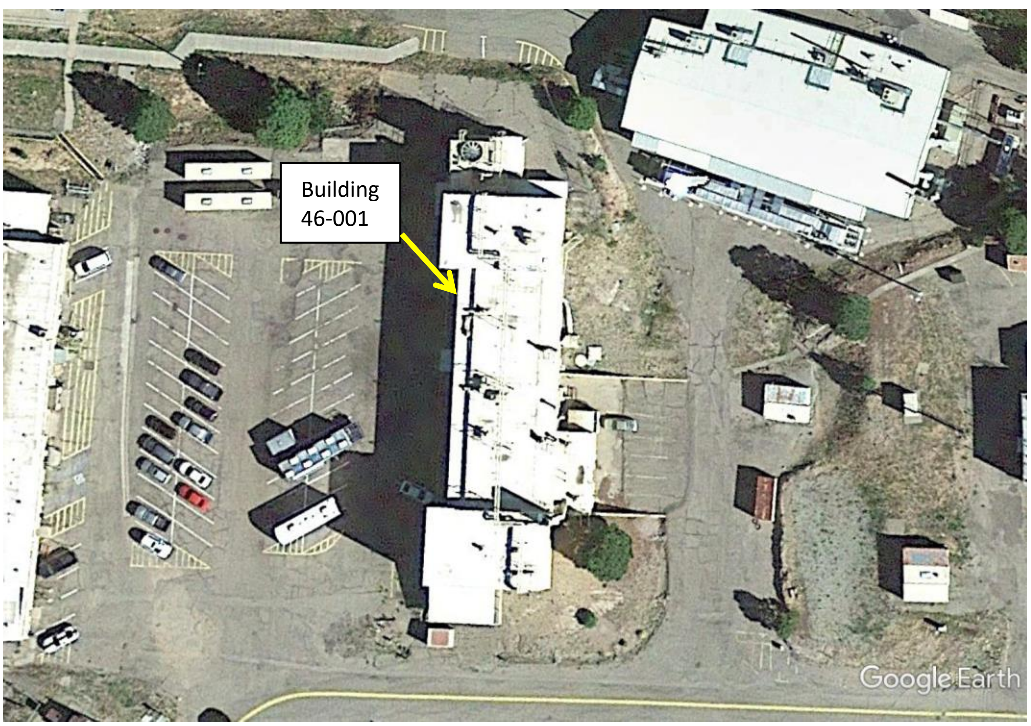


Figure 1: Aerial view of TA46 Building 1

Introduction[1]

TA-46's first building, TA-46-1, was constructed in 1954 to support weapons assembly operations, but was never used for that purpose. Over the years, TA-46 has supported the Laboratory's basic science mission. Research priorities at TA-46 have changed several times since the technical area's first use supporting Nuclear Rocket (N) Division's development of reactors for rocket propulsion. Following the termination of the Rover program in 1973, activities at TA-46 supported laser isotope separation, the production of nonradioactive isotopes of oxygen, carbon, and nitrogen, and nanoscale chemistry research (LANL 1993b; LANL 2002). In the 1970s and 1980s, Energy (Q) Division personnel also conducted solar energy experiments at TA-46, including the construction of experimental solar buildings and solar ponds. In the 1990s, scientific work focused on photochemical research involving free electron lasers and hydrogen fuel cells. Heat pipe studies, and accelerator and electronics research were also conducted during this time (LANL 1993b). Most recently, the facilities at TA-46 have been used for diverse chemistry and materials science research, including nanoscale studies in support of solar energy research.

MARSAME Survey Description

Survey Quality Objectives

The data quality and survey completeness of the characterization survey were compared to MARSAME requirements for statistical coverage and representativeness. To ensure adequacy of survey coverage, EPC-ES used the statistical software Visual Sample Plan (VSP 2014). This software generates a MARSAME-compliant sampling plan that provides sufficient and representative data on which to base release decisions. Characterization surveys provide 1) information on the nature and extent of contamination, if any, 2) data to support evaluation of remedial alternatives and technologies, 3) data for determining if the survey plan can be optimized for use in the final survey, and 4) input for the final status survey design (MARSSIM 2000).

Fundamental assumptions for this survey plan depended upon the disposition pathway and included the following:

- The data were not assumed to be normally distributed
- For the Authorized Limit release pathway (material released to commercial landfill or for recycle):
    - The null hypothesis, H_o, is that the survey unit is contaminated above the authorized limit (AL). "Passing" the survey unit, and releasing the material, would result from rejecting the null hypothesis.
    - Type 1 error (incorrectly rejecting the null hypothesis) would mean concluding the material was below the AL, when in fact it was contaminated above the AL.
    - Type 2 error (incorrectly failing to reject the null hypothesis) would mean concluding the material was contaminated above the AL when it was uncontaminated.

Measurements collected during the characterization survey were used as input for calculating the relative shift and other statistical parameters used in the sampling and analysis plan (Appendix A). Type I error was set at 5% and Type II error was set at 10%, resulting in approximately 12 samples per decision unit (i.e., per room) using VSP software (see Supplement in Appendix A). Biased and scan surveys were included in MARSAME-based plans for improved coverage and better specificity using process knowledge. Based on characterization survey coverage, no additional surveys were required for the general room surveys or the exterior and roof structures. The Final Release Survey Plan, including the exterior structures in this report, was submitted for independent review by the DOE in compliance with DOE Order 458.1 prior to release.

[1] Text directly from McGehee E, Garcia K. An assessment of Cold War-Era buildings at Technical Area 46, Los Alamos National Laboratory. Los Alamos National Laboratory report LA-UR-14-25029; 2014.

As detailed in the Sampling and Analysis Plan, smears for removable alpha, and beta radioactivity were taken according to procedures. Direct 1-minute measurements of alpha and beta/gamma measurements were also taken per procedure and evaluated as total surface activity.

The number and placement of sampling locations in the initial and follow up characterization surveys for the specified structures in this report were compared to MARSAME requirements for final release and were adequate in number of measurements and the spatial distribution to make valid statistically-based release decisions (see Table 1). Grid-like and bias (i.e., judgmental) sampling were performed in each room using direct counts and scan surveys. Table 1, presents a summary of the Sampling and Analysis Plan final status survey requirements and the corresponding survey that was actually performed.

Table 1 also provides the disposition decisions based on the radiological survey (i.e., not detectable or indistinguishable from background or LLW if above release criteria). In most cases, the rooms met the unrestricted release criteria since the radioactivity in building materials was indistinguishable from natural background, but there were several rooms where ventilation and liquid drain systems were posted for radiological contamination. Though the inside surfaces of the ventilation and liquid drain equipment were inaccessible, we assume they are contaminated and the associated material is not releasable for disposition in a commercial landfill or as recycling [NMAC-SWB-20.9.2.10(10)]. Disposition of these building materials as LLW is required.

Table 1: Final status survey requirements compared to completed surveys.

Sampling and Analysis Plan Designation			Final Status Survey Requirements			Survey Performed		
Survey Unit #	**Class**	**Description**	**Directs & Smears**	**Scanning**	**Other**	**Date(s)**	**Sampling (direct and smear)**	**Scan %**
46-1-001	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC[2]	<5%	Alpha Beta	6/6/2018	30 Grid 10 Bias 2 QC	25%
46-1-002	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	6/6/2018	30 Grid 10 Bias 2 QC	25%
46-1-003A Corridor	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	6/12/2018	30 Grid 10 Bias 2 QC	25%
46-1-003B Corridor	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	6/12/2018	20 Grid 6 Bias 1 QC	25%
46-1-004	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	5/30/2018	30 Grid 14 Bias 2 QC	25%
46-1-005	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	6/6/2018	30 Grid 10 Bias 2 QC	25%
46-1-008	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	5/30/2018	30 Grid 10 Bias 2 QC	25%
46-1-009	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	6/11/2018	30 Grid 10 Bias 2 QC	25%
46-1-011 Janitor Closet	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	6/12/2018	12 Grid 3 Bias 1 QC	25%
46-1-012 Restroom	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	6/12/2018	14 Grid 0 Bias 2 QC	25%
46-1-014	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/18/2018	30 Grid 10 Bias 2 QC	25%
46-1-016	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	6/11/2018	30 Grid 10 Bias 2 QC	25%

[2] QC- Quality Control (a replicate measurement)

Sampling and Analysis Plan Designation			Final Status Survey Requirements			Survey Performed		
Survey Unit #	Class	Description	Directs & Smears	Scanning	Other	Date(s)	Sampling (direct and smear)	Scan %
46-1-017	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	6/6/2018	30 Grid 14 Bias 2 QC	25%
46-1-024	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	6/11/2018	30 Grid 10 Bias 2 QC	25%
46-1-027	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	6/11/2018	30 Grid 10 Bias 2 QC	25%
46-1-028	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	5/9/2018	30 Grid 10 Bias 2 QC	25%
46-1-419	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	5/8/2018	30 Grid 10 Bias 1 QC	25%
46-1-Annex#1	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	5/1/2018	30 Grid 10 Bias 2 QC	25%
46-1-Annex#2	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	5/2/2018	30 Grid 10 Bias 2 QC	25%
46-1-Main Hallway	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/13/2018	56 Grid 10 Bias 2 QC	25%
46-1-South Hallway	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/13/2018	20 Grid 6 Bias 2 QC	25%
46-1-North Hallway	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/13/2018	20 Grid 6 Bias 2 QC	25%
46-1-Stairwell 1st to 2nd Flr	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/30/2018	35 Grid 5 Bias 2 QC	25%
46-1-Stairwell 1st to Basement	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	6/12/2018	22 Grid 0 Bias 2 QC	25%
46-1-101	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/10/2018	30 Grid 10 Bias 2 QC	25%
46-1-102	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	3/13/2018	30 Grid 10 Bias 2 QC	25%

Sampling and Analysis Plan Designation			Final Status Survey Requirements			Survey Performed		
Survey Unit #	Class	Description	Directs & Smears	Scanning	Other	Date(s)	Sampling (direct and smear)	Scan %
46-1-103	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	5/9/2018	30 Grid 10 Bias 2 QC	25%
46-1-104	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/16/2018	12 Grid 2 Bias 1 QC	25%
46-1-105	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	5/31/2018	30 Grid 10 Bias 2 QC	25%
46-1-106	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	3/19/2018	30 Grid 10 Bias 2 QC	25%
46-1-107	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/12/2018	30 Grid 10 Bias 2 QC	25%
46-1-112	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	3/28/2018	30 Grid 10 Bias 2 QC	25%
46-1-115	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/10/2018	25 Grid 10 Bias 2 QC	25%
46-1-118	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	3/28/2018	30 Grid 10 Bias 2 QC	25%
46-1-121	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/11/2018	30 Grid 10 Bias 2 QC	25%
46-1-122	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/2/2018	30 Grid 10 Bias 2 QC	25%
46-1-122A	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/2/2018	30 Grid 10 Bias 2 QC	25%
46-1-123	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/11/2018	30 Grid 10 Bias 2 QC	25%
46-1-127	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/11/2018	30 Grid 10 Bias 2 QC	25%
46-1-128	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/12/2018	30 Grid 10 Bias 2 QC	25%

Sampling and Analysis Plan Designation			Final Status Survey Requirements			Survey Performed		
Survey Unit #	Class	Description	Directs & Smears	Scanning	Other	Date(s)	Sampling (direct and smear)	Scan %
46-1-Bay 100	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	5/28/2018	55 Grid 14 Bias 2 QC	25%
46-1-Bay 130	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	5/26/2018	39 Grid 16 Bias 4 QC	25%
46-1-Bay 131	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	5/29/2018	30 Grid 10 Bias 2 QC	25%
46-1-Bay 133	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	5/1/2018	30 Grid 10 Bias 2 QC	25%
46-1-Exterior	3	walls	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	6/13/2018	30 Grid	25%
46-1-203	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/16/2018	30 Grid 10 Bias 2 QC	~25%
46-1-204	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/16/2018	30 Grid 10 Bias 2 QC	~25%
46-1-205	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/17/2018	30 Grid 10 Bias 2 QC	~25%
46-1-206	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/16/2018	30 Grid 10 Bias 2 QC	~25%
46-1-207	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/18/2018	30 Grid 10 Bias 2 QC	~25%
46-1-208	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/17/2018	30 Grid 10 Bias 2 QC	~25%
46-1-210	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/18/2018	30 Grid 10 Bias 2 QC	~25%
46-1-211	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/16/2018	30 Grid 10 Bias 2 QC	~25%
46-1-212	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/18/2018	30 Grid 10 Bias 2 QC	~25%

Sampling and Analysis Plan Designation			Final Status Survey Requirements			Survey Performed		
Survey Unit #	**Class**	**Description**	**Directs & Smears**	**Scanning**	**Other**	**Date(s)**	**Sampling (direct and smear)**	**Scan %**
46-1-200 Hall	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/25/2018	50 Grid 10 Bias 2 QC	~25%
46-1-215 Janitor Closet	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/18/2018	10 Grid 5 Bias 1 QC	~25%
46-1-216	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/19/2018	30 Grid 10 Bias 2 QC	~25%
46-1-217	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/25/2018	30 Grid 10 Bias 1 QC	~25%
46-1-219	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/19/2018	30 Grid 10 Bias 2 QC	~25%
46-1-222	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/19/2018	30 Grid 10 Bias 2 QC	~25%
46-1-223A	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/23/2018	30 Grid 10 Bias 2 QC	~25%
46-1-223B	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/23/2018	30 Grid 10 Bias 2 QC	~25%
46-1-223 Hallway	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/23/2018	11 Grid 1 Bias 1 QC	~25%
46-1-224	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/24/2018	30 Grid 10 Bias 2 QC	~25%
46-1-226	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/24/2018	30 Grid 10 Bias 2 QC	~25%
46-1-227	3	floors, walls, ceiling	~25 Grid ~10 Biased ~10% QC	<5%	Alpha Beta	4/24/2018	30 Grid 10 Bias 2 QC	~25%

3

Figure 2 – Floor plan for basement

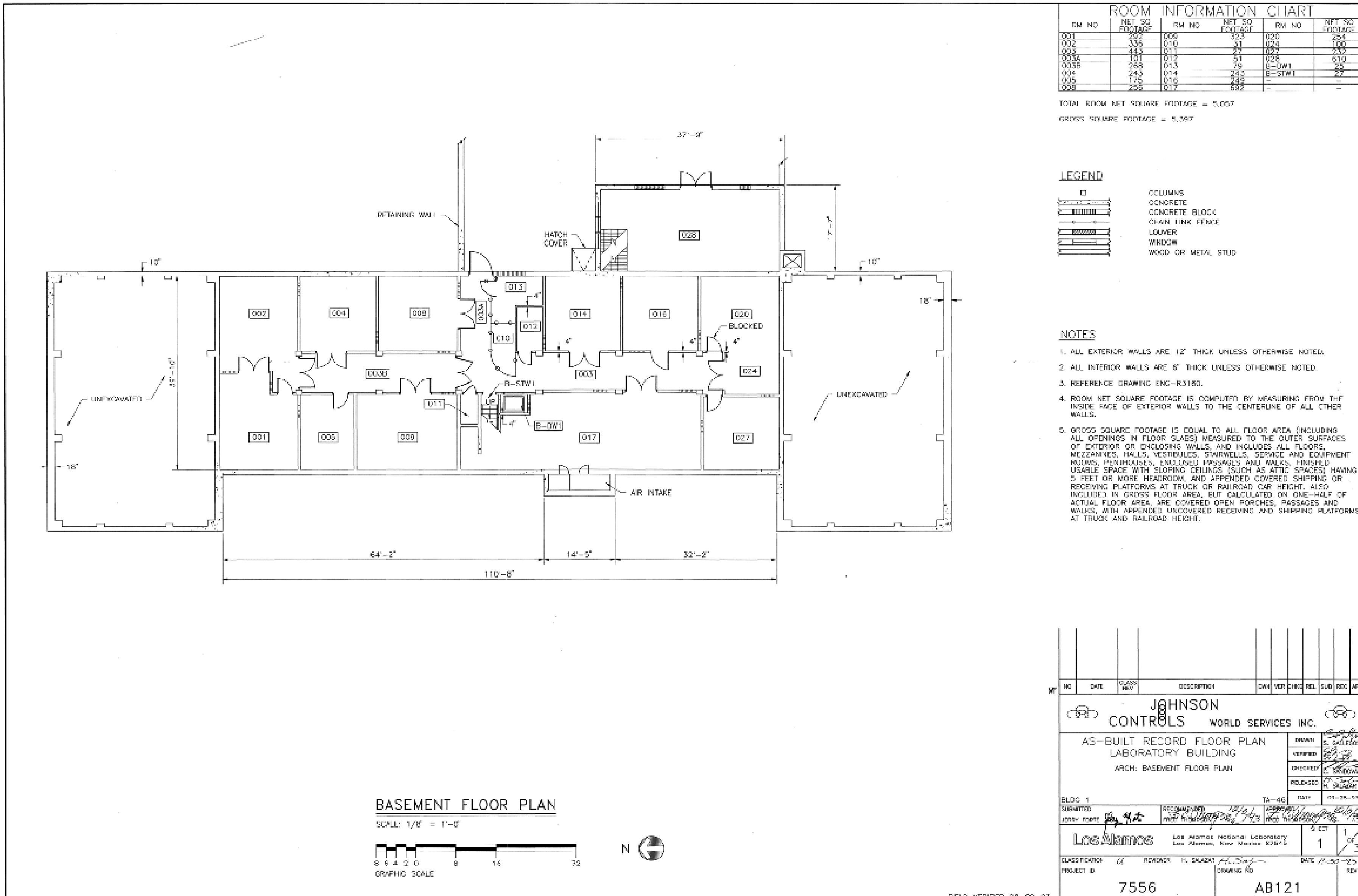


Figure 3 – Floor plan for first floor

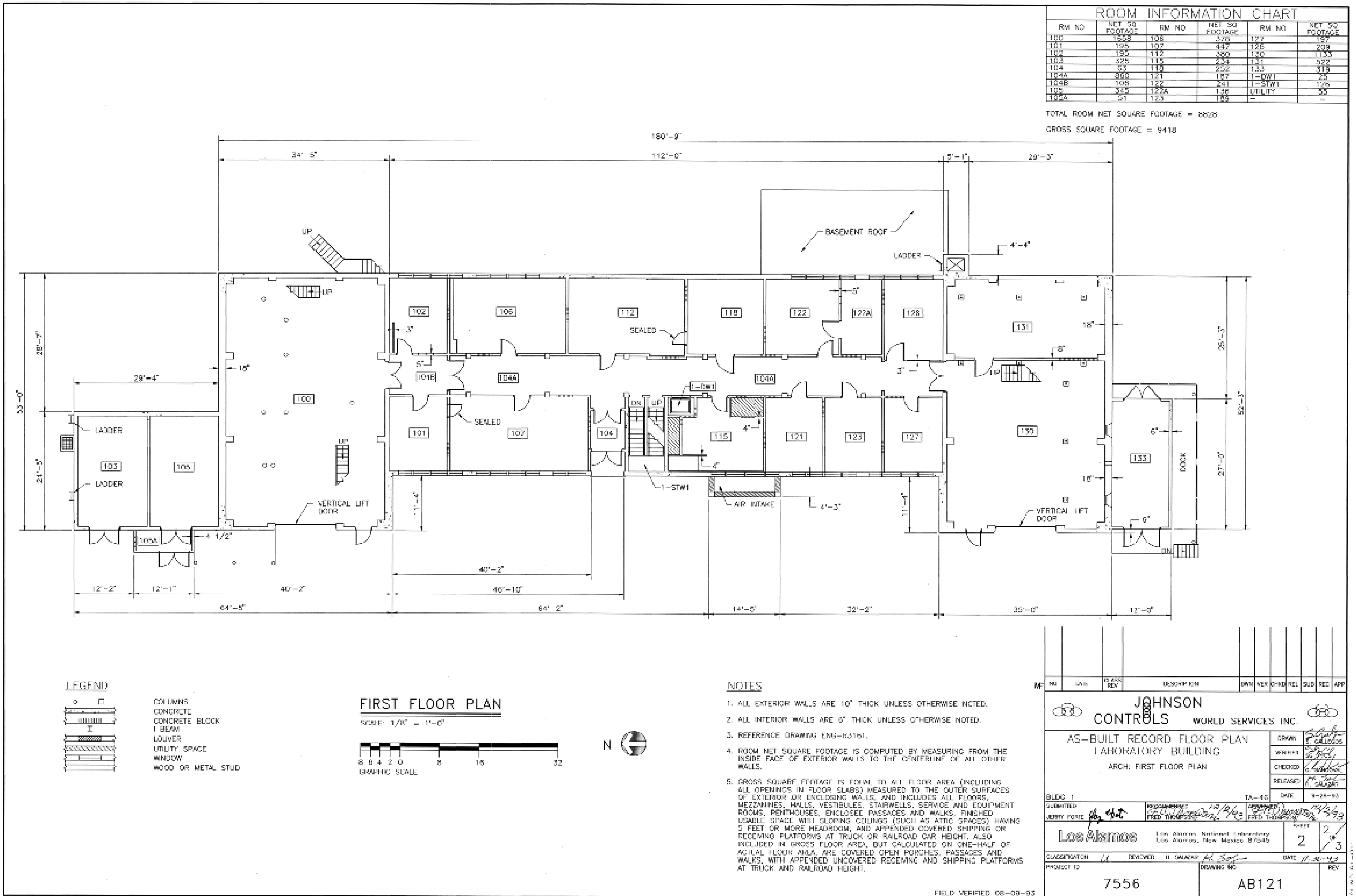
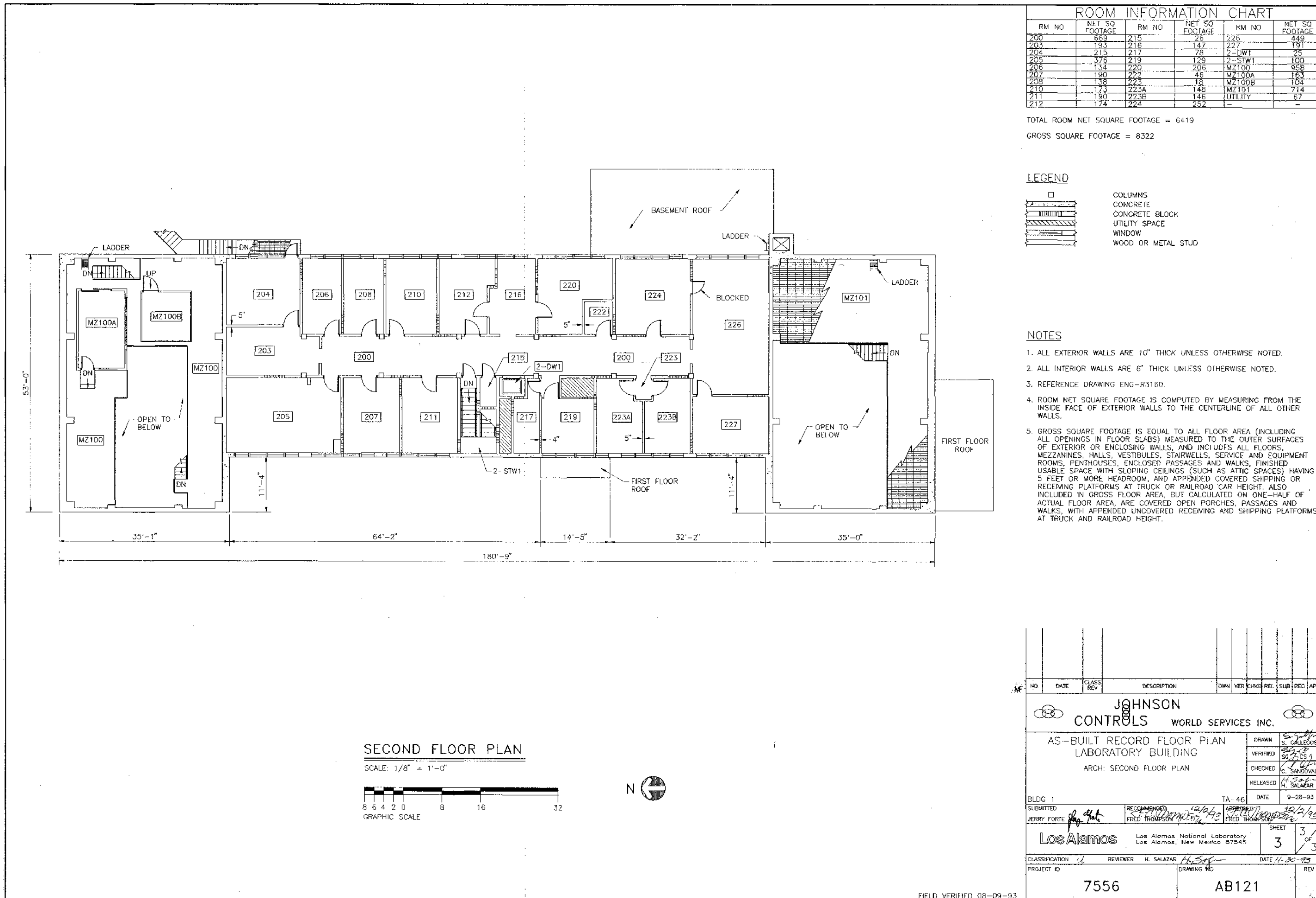


Figure 4 – Floor plan for second floor



RM NO	NET SQ FOOTAGE	RM NO	NET SQ FOOTAGE	RM NO	NET SQ FOOTAGE
200	669	215	26	226	449
203	193	216	147	227	191
204	215	217	78	2-DW1	25
205	376	219	129	2-STW1	100
206	134	220	206	MZ100	958
207	190	222	46	MZ100A	163
208	138	223	18	MZ100B	104
210	173	223A	148	MZ101	714
211	190	223B	146	UTILITY	67
212	174	224	252	–	–

Measurement Quality Objectives

1. The items and materials included in this report were classified as Class 3 (minimal potential for contamination), consistent with MARSAME. Sampling and analysis protocol for these items was consistent with LANL policy and procedures (LANL 2015). Direct measurements were made using a Ludlum 43-93Alpha/Beta probe coupled with a Thermo RadEye instrument. This instrument is appropriate for alpha/beta surface contamination measurements. Smears were used to collect removable samples and were counted using a Berthold 2010/143. The minimum detectable activity (MDAs) for the direct surveys were below the release limits in Table 10-2 in EPC-ES-FSD-004, as required. Smears were counted on a Berthold Model 2010/143 Alpha/Beta Counter with MDAs that were approximately 6 dpm alpha and 11 dpm beta.
2. This assessment confirms that the measurement quality objectives were met for the disposition of the materials, specifically:
   a. Appropriate instrumentation and techniques were used for the measurements and the expected radionuclides (Pu-239, uranium and tritium were identified as the dominant radionuclides for surface contamination);
   b. Scanning surveys (at least 10% coverage for Class 3) were used to search for hot spots, as documented in the characterization surveys;
   c. Instruments were calibrated, response checked and background measurements were within expected ranges; and
   d. Minimum detectable concentrations of the measurements were calculated to be below the surface radioactivity values in Table 10-2 of EPC-ES-FSD-004.

Statistical Objectives for Disposition Pathways

Depending on the disposition pathway, the objectives of the measurements were to confirm, within the stated statistical confidence limits, that:

1. Measurements of total and removable surface radioactivity are below Table 10-2 values in EPC-ES-FSD-004; and/or
2. Potential residual radioactive contamination is within background levels [i.e. sample measurement distribution is statistically indistinguishable from background distribution (IFB)].

Potential disposition pathways for this project included:

1. Release of metal for recycle using the Authorized Limits for surface radioactivity found in EPC-ES-FSD-004 Table 10-2 and as low as reasonably achievable (ALARA) considerations. However, metal materials associated with ventilation systems and liquid drains were identified early on for disposition as LLW based on radiological postings and inaccessible surfaces for surveys.
2. Release of concrete for recycle using a release criterion of IFB. The concrete within building 1 met the IFB criterion and may be a candidate for recycling.
3. Release of construction and demolition debris (all other material) for disposal at commercial/municipal landfills using a release criterion of IFB.
4. Low Level Waste disposal for any material that does not meet release requirements for any of the above (items 1-3) disposition pathways.

Data Analysis

Authorized Limit Release Pathway

Materials bearing surface radioactivity greater than the MDA were evaluated by comparison to the preapproved ALs found in Table 10-2 of EPC-ES-FSD-004. The radionuclide of concern for surface radioactivity was plutonium (alpha measurements) and uranium (beta measurements), which have preapproved release limits of 1) 20 dpm/100 cm^2 and 100 dpm/100 cm^2 for removable and total alpha activity, and 2) 1000 dpm/100 cm^2 removable and 5000 dpm/100 cm^2 total for beta activity.

Decision Criteria for AL pathway:

- If all measurements are 1) ≤ AL, or 2) < table values for items with surface contamination potential only (e.g. Table 10-2 in EPC-ES-FSD-004), then no further action is required and the items are candidates for unrestricted release.
- If all measurements or the 95% upper confidence limit (UCL) are > the AL, then the item is not a candidate for release through the AL release pathway and the items can be considered for decontamination or decay in storage followed by resampling before it can be released.
- If the UCL for a set of measurements is below the AL, but some individual measurements are above the AL, then statistical analysis is needed. Generally, non-parametric statistical approaches are used to evaluate the null hypothesis. If contamination is present in background, the Wilcoxon Rank Sum test is used, and if contamination is not present in background, use the Sign Test.

Indistinguishable From Background Pathway

Materials bearing surface radioactivity greater than the MDA were evaluated by comparison to the reference background values for common construction materials with naturally occurring radioactive material (NORM) found in Bullock et al. (2018), see Attachment 1. Without pre-approved volumetric limits, the IFB release criterial were applied for these releases.

Decision Criteria for IFB pathway:

a. IFB release pathway:
    - If all measurements are: 1) ≤ detectable levels, or 2) < reference background values such as the 95% UCL, then no further action is required and the items are candidates for unrestricted release.
    - If all measurements are > 95%UCL of background, then the item is not a candidate for release through the IFB pathway and the item can be considered for decontamination or decay in storage followed by resampling before it can be released.
    - If the mean for a set of measurements is below the 95% UCL background level, but some individual measurements are above the 95%UCL level, then statistical analysis is needed. Generally, non-parametric statistical approaches are used to evaluate the null hypothesis. If contamination is present in background, the Wilcoxon Rank Sum test is suggested, and if contamination is not present in background, use the Sign Test.

Results

Surface Sampling Results

Results of surveys conducted on building materials are provided in Table 2, where they are grouped by room and then compared to AL criteria. These surface radioactivity results show that most of the materials were below the limits found in EPC-ES-FSD-004 Table 10-2. However, given the history of the operations within the building and that the interior of surfaces are not easily accessible for survey, all ventilation and plumbing drains shall be segregated from other building debris and managed as LLW.

Table 2: Summary statistics for gross alpha and beta surface radioactivity levels in sampling and release decisions. Units are dpm/100 cm^2. Acronyms provided at end of table.

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
46-1 Basement									
46-1-001	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0.4	2.7	16.9	2.3	1000	< AL, IFB
	total	alpha	42	13	6	24	17	100	< AL, IFB
		beta	42	1089	236	1654	1154	5000	< AL, IFB
46-1-002	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0.4	2.7	16.9	2.3	1000	< AL, IFB
	total	alpha	42	13	6	27	15	100	< AL, IFB
		beta	42	1033	244	1613	1100	5000	< AL, IFB
46-1-3A	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	14	8	44	16	100	< AL, IFB
		beta	42	1126	339	1854	1214	5000	< AL, IFB
46-1-3B	removable	alpha	26	0	0	0	0	20	< AL, IFB
		beta	26	0	0	0	0	1000	< AL, IFB
	total	alpha	27	13	6	24	15	100	< AL, IFB
		beta	27	1098	314	1696	1201	5000	< AL, IFB
46-1-004	removable	alpha	44	0	0	0	0	20	< AL, IFB
		beta	44	0.4	2.5	16.9	2.1	1000	< AL, IFB
	total	alpha	46	11	6	27	13	100	< AL, IFB
		beta	46	1045	259	1783	1109	5000	< AL, IFB
46-1-005	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	15	6	27	19	100	< AL, IFB
		beta	42	1109	268	1769	1178	5000	< AL, IFB
46-1-008	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	10	8	44	15	100	< AL, IFB
		beta	42	1098	290	1643	1174	5000	< AL, IFB
46-1-009	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	29	9	49	32	100	< AL, IFB
		beta	42	971	182	1530	1019	5000	< AL, IFB
46-1-011	removable	alpha	15	0	0	0	0	20	< AL, IFB
		beta	15	0	0	0	0	1000	< AL, IFB
	total	alpha	16	35	35	100	73	100	< AL, IFB
		beta	16	1195	465	1808	1399	5000	< AL, IFB

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
46-1-012	removable	alpha	16	0	0	0	0	20	< AL, IFB
		beta	16	0	0	0	0	1000	< AL, IFB
	total	alpha	18	6	7	20	13	100	< AL, IFB
		beta	18	1226	371	1752	1378	5000	< AL, IFB
46-1-014	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0.3	1.7	10.6	1.4	1000	< AL, IFB
	total	alpha	42	10	7	22	15	100	< AL, IFB
		beta	42	1080	279	1685	1152	5000	< AL, IFB
46-1-016	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	13	7	26	17	100	< AL, IFB
		beta	42	1216	458	3462	1335	5000	< AL, IFB
46-1-017	removable	alpha	44	0	0	0	0	20	< AL, IFB
		beta	44	0	0	0	0	1000	< AL, IFB
	total	alpha	46	15	7	24	19	100	< AL, IFB
		beta	46	977	272	1783	1045	5000	< AL, IFB
46-1-024	removable	alpha	40	0.2	1.2	7.3	1	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	13	7	26	18	100	< AL, IFB
		beta	42	1029	299	1952	1106	5000	< AL, IFB
46-1-027	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	9	6	22	13	100	< AL, IFB
		beta	42	1028	242	1634	1091	5000	< AL, IFB
46-1-028	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	10	5	20	13	100	< AL, IFB
		beta	42	888	133	1324	924	5000	< AL, IFB
46-1-419	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	41	9	5	21	12	100	< AL, IFB
		beta	41	944	208	1509	999	5000	< AL, IFB
46-1 First Floor									
46-1-Annex#1	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	13	6	20	16	100	< AL, IFB
		beta	42	931	155	1271	971	5000	< AL, IFB
46-1-Annex#2	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	10	6	21	14	100	< AL, IFB
		beta	42	895	178	1277	941	5000	< AL, IFB

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
46-1-Annex#3	removable	alpha	14	0	0	0	0	20	< AL, IFB
		beta	14	0	0	0	0	1000	< AL, IFB
	total	alpha	15	8	6	19	11	100	< AL, IFB
		beta	15	1163	302	1637	1300	5000	< AL, IFB
46-1-Main Hallway	removable	alpha	66	0	0	0	0	20	< AL, IFB
		beta	66	0	0	0	0	1000	< AL, IFB
	total	alpha	68	8	7	26	12	100	< AL, IFB
		beta	68	981	229	1605	1026	5000	< AL, IFB
46-1-South Hallway	removable	alpha	26	0	0	0	0	20	< AL, IFB
		beta	26	0	0	0	0	1000	< AL, IFB
	total	alpha	28	10	7	22	12	100	< AL, IFB
		beta	28	930	287	1731	1030	5000	< AL, IFB
46-1-North Hallway	removable	alpha	26	0	0	0	0	20	< AL, IFB
		beta	26	0	0	0	0	1000	< AL, IFB
	total	alpha	28	8	7	30	14	100	< AL, IFB
		beta	28	904	230	1514	978	5000	< AL, IFB
46-1-Stairwell 1st to 2nd Flr	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	10	6	29	14	100	< AL, IFB
		beta	42	1177	270	1810	1247	5000	< AL, IFB
46-1-Stairwell 1st to Basement	removable	alpha	22	0	0	0	0	20	< AL, IFB
		beta	22	0	0	0	0	1000	< AL, IFB
	total	alpha	24	12	6	24	14	100	< AL, IFB
		beta	24	932	100	1118	967	5000	< AL, IFB
46-1-101	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	16	25	165	33	100	< AL, IFB
		beta	42	1102	255	1630	1169	5000	< AL, IFB
46-1-102	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	12	7	30	17	100	< AL, IFB
		beta	42	1047	256	1772	1114	5000	< AL, IFB
46-1-103	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	12	5	19	13	100	< AL, IFB
		beta	42	896	138	1097	932	5000	< AL, IFB
46-1-104	removable	alpha	14	0	0	0	0	20	< AL, IFB
		beta	14	0	0	0	0	1000	< AL, IFB
	total	alpha	15	9	6	22	13	100	< AL, IFB
		beta	15	1137	299	1906	1273	5000	< AL, IFB

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
46-1-105	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	12	7	27	17	100	< AL, IFB
		beta	42	826	118	1004	858	5000	< AL, IFB
46-1-106	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	13	8	35	19	100	< AL, IFB
		beta	42	1248	298	1749	1325	5000	< AL, IFB
46-1-107	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	13	6	26	17	100	< AL, IFB
		beta	42	1294	296	2016	1371	5000	< AL, IFB
46-1-112	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	11	7	31	16	100	< AL, IFB
		beta	42	1302	290	1786	1377	5000	< AL, IFB
46-1-115	removable	alpha	35	0	0	0	0	20	< AL, IFB
		beta	35	0	0	0	0	1000	< AL, IFB
	total	alpha	37	33	34	133	58	100	< AL, IFB
		beta	37	1669	495	2360	1806	5000	< AL, IFB
46-1-118	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	20	20	126	33	100	< AL, IFB
		beta	42	1328	302	2107	1406	5000	< AL, IFB
46-1-121	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	11	12	74	20	100	< AL, IFB
		beta	42	1255	315	1857	1343	5000	< AL, IFB
46-1-122	removable	alpha	40	0.3	1.8	11.3	1.5	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	10	9	39	16	100	< AL, IFB
		beta	42	1165	251	1928	1230	5000	< AL, IFB
46-1-122A	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0.3	2	12.6	1.7	1000	< AL, IFB
	total	alpha	42	8	5	18	12	100	< AL, IFB
		beta	42	1331	1282	9241	1664	5000	< AL, IFB
46-1-123	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	10	8	31	16	100	< AL, IFB
		beta	42	1293	283	1798	1373	5000	< AL, IFB

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
46-1-127	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	19	18	102	30	100	< AL, IFB
		beta	42	1076	246	1648	1139	5000	< AL, IFB
46-1-128	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	13	6	26	18	100	< AL, IFB
		beta	42	1053	207	1679	1107	5000	< AL, IFB
46-1-Bay 100	removable	alpha	70	0	0	0	0	20	< AL, IFB
		beta	70	0.5	2.8	16.9	1.9	1000	< AL, IFB
	total	alpha	72	13	7	27	17	100	< AL, IFB
		beta	72	850	121	1161	874	5000	< AL, IFB
46-1-Bay 130	removable	alpha	55	0	0	0	0	20	< AL, IFB
		beta	55	0	0	0	0	1000	< AL, IFB
	total	alpha	59	11	6	23	15	100	< AL, IFB
		beta	59	935	190	1470	977	5000	< AL, IFB
46-1-Bay 131	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	10	5	22	14	100	< AL, IFB
		beta	42	970	236	1629	1032	5000	< AL, IFB
46-1-Bay 133	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0.4	2.3	14.4	1.9	1000	< AL, IFB
	total	alpha	42	8	5	20	12	100	< AL, IFB
		beta	42	889	76	1053	908	5000	< AL, IFB
46-1-Exterior	removable	alpha	30	0	0	0	0	20	< AL, IFB
		beta	30	0.6	3.1	16.9	3	1000	< AL, IFB
	total	alpha	30	25	8	39	28	100	< AL, IFB
		beta	30	1051	139	1237	1094	5000	< AL, IFB
46-1 Second Floor									
46-1-203	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	14	9	36	20	100	< AL, IFB
		beta	42	1255	291	2098	1331	5000	< AL, IFB
46-1-204	removable	alpha	40	0	1	6	1	20	< AL, IFB
		beta	40	0	2	14	2	1000	< AL, IFB
	total	alpha	42	14	12	80	22	100	< AL, IFB
		beta	42	1189	271	2093	1259	5000	< AL, IFB
46-1-205	removable	alpha	40	0.2	1	6.2	0.8	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	13	8	27	18	100	< AL, IFB
		beta	42	1168	313	1829	1256	5000	< AL, IFB

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
46-1-206	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	19	20	96	32	100	< AL, IFB
		beta	42	1397	316	2167	1479	5000	< AL, IFB
46-1-207	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	9	5	18	12	100	< AL, IFB
		beta	42	1378	283	1842	1452	5000	< AL, IFB
46-1-208	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	15	16	92	25	100	< AL, IFB
		beta	42	1463	323	2082	1547	5000	< AL, IFB
46-1-210	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	10	7	22	14	100	< AL, IFB
		beta	42	1389	265	2097	1458	5000	< AL, IFB
46-1-211	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	11	11	48	18	100	< AL, IFB
		beta	42	1444	302	2022	1522	5000	< AL, IFB
46-1-212	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	13	11	47	20	100	< AL, IFB
		beta	42	1392	261	1869	1460	5000	< AL, IFB
46-1-200 Hall	removable	alpha	60	0	0	0	0	20	< AL, IFB
		beta	60	0	0	0	0	1000	< AL, IFB
	total	alpha	62	13	7	26	16	100	< AL, IFB
		beta	62	1137	300	1764	1203	5000	< AL, IFB
46-1-215 Janitor Closet	removable	alpha	15	0	0	0	0	20	< AL, IFB
		beta	15	0	0	0	0	1000	< AL, IFB
	total	alpha	16	26	27	111	42	100	< AL, IFB
		beta	16	1502	415	2266	1684	5000	< AL, IFB
46-1-216	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	9	5	18	13	100	< AL, IFB
		beta	42	1325	235	1773	1385	5000	< AL, IFB
46-1-217	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	41	29	34	119	52	100	< AL, IFB
		beta	41	1438	441	2221	1554	5000	< AL, IFB

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
46-1-219	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	9	6	24	10	100	< AL, IFB
		beta	42	1161	256	1778	1228	5000	< AL, IFB
46-1-222	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	10	5	22	13	100	< AL, IFB
		beta	42	1188	234	1704	1249	5000	< AL, IFB
46-1-223A	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	11	5	21	12	100	< AL, IFB
		beta	42	1234	247	1781	1298	5000	< AL, IFB
46-1-223B	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	10	5	17	13	100	< AL, IFB
		beta	42	1128	304	1893	1207	5000	< AL, IFB
46-1-223 Hall	removable	alpha	12	0	0	0	0	20	< AL, IFB
		beta	12	0	0	0	0	1000	< AL, IFB
	total	alpha	13	12	6	18	14	100	< AL, IFB
		beta	13	962	175	1197	1048	5000	< AL, IFB
46-1-224	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	10	7	22	14	100	< AL, IFB
		beta	42	1157	275	1675	1228	5000	< AL, IFB
46-1-226	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	9	6	22	13	100	< AL, IFB
		beta	42	1131	202	1554	1184	5000	< AL, IFB
46-1-227	removable	alpha	40	0	0	0	0	20	< AL, IFB
		beta	40	0	0	0	0	1000	< AL, IFB
	total	alpha	42	12	6	21	13	100	< AL, IFB
		beta	42	1174	209	1634	1228	5000	< AL, IFB

Acronyms:
AL- Authorized Limit
IFB – Indistinguishable from Background
Max- Maximum
n - Number of samples
STD- Standard Deviation
UCL- Upper Confidence Level (taken as the 95% upper-bound estimate of the mean)

Gamma Spectrum Measurements

Ceramic tile in rooms 115, 215, and 217 showed counts above the 95% UCL of background. EPC-ES health physics staff performed gamma spectroscopy measurements in TA-46-001 to determine the cause of the elevated direct count results. Measurements of approximately five minutes were taken at four locations where the elevated direct counts were measured. For comparison to background, one 36-hour background gamma spectral measurement was also taken away from the building.

Analysis of the spectra taken inside the building and the background spectrum reveals peaks identified as Tl-208, Bi-214, and Ac-228, which are decay isotopes of naturally occurring U-238 and Th-232. K-40 is naturally occurring in background and was present in the spectra. Peaks identified as Pb-212 (239 keV) and Ac-228 (338 keV) can also be seen on the spectra inside the building. These two peaks are also in the background spectrum, but are much smaller and much more difficult to decipher against background. The isotopes found are consistent with naturally occurring thorium. Analysis of the count rate in the 2615 keV Tl-208 peak reveals that the count rate in the building is 2-3 times higher than the count rate in background. The conclusion is that the building material contains higher than usual concentrations of natural thorium. This explains the IFB failure for all measurements made in the TA-46-001 building. No LANL-derived isotopes were found.

The conclusion is that TA-46-001 contains building materials with higher than usual natural thorium and therefore meets the IFB criteria.

Concrete Floors

During the D&D of TA-46 Building 1 (TA-46-0001), a cabinet was removed in room 102 and subsequent surveys indicated elevated direct readings on asbestos floor tile under the cabinet. As a precaution, all asbestos floor tiles in the building, including those in room 102, were removed and treated as radioactive waste pending further surveys.

Once all asbestos tiles were removed, the bare, concrete floors in the whole building were re-surveyed. For each room the following alpha & beta surveys were completed:

- 75% coverage scan surveys,
- direct and smear surveys at 12 grid plus 2 bias locations,
- and direct surveys for quality assurance at 2 locations.

Surveys were completed as follows: surface scan surveys using a Ludlum 43-93/Thermo-Fisher RadEye (α / β) detector; 60-second scalar direct surveys using a Ludlum 43-93/Thermo-Fisher RadEye (α / β); and smears counted by the Health Physics Analysis Lab (HPAL) for α and β. These measurements met Measurement Quality Objectives outlined in the TA-46-0001 Sampling and Analysis Plan.

Statistical analysis of the survey results was performed in accordance with EPC-ES-TPP-001, *Data Quality Objectives for Measurement of Radioactivity in or on Items for Transfer Into the Public Domain*. The analysis found that the data satisfied the indistinguishable from background (IFB) release pathway. Criteria for IFB are:

- If all measurements are 1) ≤ detectable levels, or 2) < reference background values such as the 95% UCL, then no further action is required and the items are candidates for unrestricted release.
- If the mean for a set of measurements is below the 95% UCL background level, but some individual measurements are above the 95% UCL level, then further statistical analysis is needed. Generally, non-parametric statistical approaches are used to evaluate the null hypothesis. If contamination is present in background, the Wilcoxon Rank Sum test is used, and if contamination is not present in background, use the Sign Test.

Conclusions

Given the process knowledge and survey data presented in this report package, EPC-ES concludes that the structures and materials associated with TA46 Building 1 can be free released under DOE Order 458.1. Concrete and metals from these areas are candidates for recycling, and other materials satisfied the radiological release criteria of indistinguishable from background for release to landfills. Final waste disposition decisions for radiological and non-radiological constituents require appropriate approvals from the waste management organization. These conclusions were found to be valid for surveys completed on concrete floors during D&D activities discussed in the previous section.

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Title 20 Chapter 9 Part 2 New Mexico Solid Waste Rules, NMAC-SWB-20.9.2.10(10). 2007.

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Attachments & Appendices

Attachment 1: Summary statistics for measured total surface activities in various common construction materials for Ludlum 43-93Alpha/Beta probe coupled with a Thermo RadEye instrument.

Appendix A: TA-46 D&D MARSSIM Characterization Survey Plan Structures: TA 46-001 Building 4, Rev. 0, Dated 1/3/2018

Attachment 1

Summary statistics for measured total surface activities in various common construction materials for Ludlum 43-93Alpha/Beta probe coupled with a Thermo RadEye instrument. Units of measurement are GROSS dpm/100 cm^2. Data from Bullock et al. (2018).

Construction Material	Mean	Maximum	Standard Deviation	95% upper confidence level for mean
Wood (n=10)				
Alpha	29	93	29	47
Beta	906	1170	147	992
Painted Metal Interior (n=27)				
Alpha	54	592	134	167
Beta	1049	1413	148	1098
Painted Metal Exterior (n=25)				
Alpha	45	73	14	50
Beta	827	1269	185	891
Beta/Alpha Ratio	18			
Rusted Metal (n=11)				
Alpha	326	569	161	415
Beta	1355	1607	211	1471
Galvanized Metal (n=8)				
Alpha	65	93	19	78
Beta	790	869	66	834
Bare Metal (n=25)				
Alpha	12	29	7	15
Beta	1237	1632	252	1324
Painted Concrete Poured Interior (n=30)				
Alpha	20	47	12	24
Beta	1547	2427	291	1638
Painted Concrete Poured Exterior (n=20)				
Alpha	26	63	13	31
Beta	1363	1688	204	1688
Bare Concrete Poured Interior (n=25)				
Alpha	27	107	32	56
Beta	1538	1948	360	1853

Construction Material	Mean	Maximum	Standard Deviation	95% upper confidence level for mean
Bare Concrete Poured Exterior (n=20)				
Alpha	83	155	44	100
Beta	1757	2247	238	2235
Painted Cinderblock (n=25)				
Alpha	27	68	17	33
Beta	1938	2248	276	2033
Bare Cinderblock Exterior (n=20)				
Alpha	66	128	31	78
Beta	1774	2695	477	1986
Brick (n=25)				
Alpha	95	179	47	111
Beta	2153	2660	458	2311
Ceiling tile (n=25)				
Alpha	23	43	10	27
Beta	1493	1854	156	1547
Floor tile (n=25)				
Alpha	9	30	7	11
Beta	1156	1460	129	1200
Porcelain (n=25)				
Alpha	59	123	25	68
Beta	2149	2621	198	2217
Ceramic Tile (n=25)				
Alpha	20	53	12	25
Beta	1932	2316	327	2045
Carpet (n=9)				
Alpha	184	600	242	687
Beta	1122	1345	144	1212
Composite Laminates[1] (n=19)				
Alpha	253	1423	392	645
Beta	1193	2100	311	1315
Painted Wallboard (n=7)				
Alpha	178	601	260	1157
Beta	1020	1507	273	1221
Stucco (n=7)				
Alpha	46	53	6	51

Construction Material	Mean	Maximum	Standard Deviation	95% upper confidence level for mean
Beta	1099	1245	120	1188
Glass (n=5)				
Alpha	13	17	3	16
Beta	940	997	58	995
Rubber (n=25)				
Alpha	17	39	9	20
Beta	1133	1770	318	1255
Roofing Composite[2] (n=10)				
Alpha	44	88	27	60
Beta	1344	1596	172	1444

[1] Composite Laminates: laminated tables, laminated counter, plastic, and linoleum
[2] Composite Roofing: Asphalt and gravel

Appendix A

TA-46 D&D MARSSIM Characterization Survey

Plan Structures: TA 46 Building 1

TA-46 D&D MARSSIM Characterization Survey Plan
Structures: TA 46-001
Rev. 0, Draft Dated 1/3/2018

1. Purpose and Scope of the TA-46, Bld 001 D&D MARSSIM Characterization Plan

Building 46-001 and associated structures need to be characterized to support future Decontamination & Demolition (D&D) of these structures. The building and structures have some, but limited history of radiological work. There is ductwork that is posted for internal contamination. Thus, the building and structures within this Plan have reasonable potential for radiological impact in some areas. Given uncertainty in historical knowledge, a limited characterization survey is proposed here to guide MARSAME surveys and future D&D. Since the structures are still standing, the MARSSIM survey approach will be utilized to perform the characterization surveys of these structures for residual radioactive contamination. However, since these structures will eventually be demolished and the waste and any recyclable materials will be sent offsite for disposal, the MARSAME requirements will be utilized to evaluate the resulting characterization data for waste debris and recyclable material disposal path decisions, as appropriate.

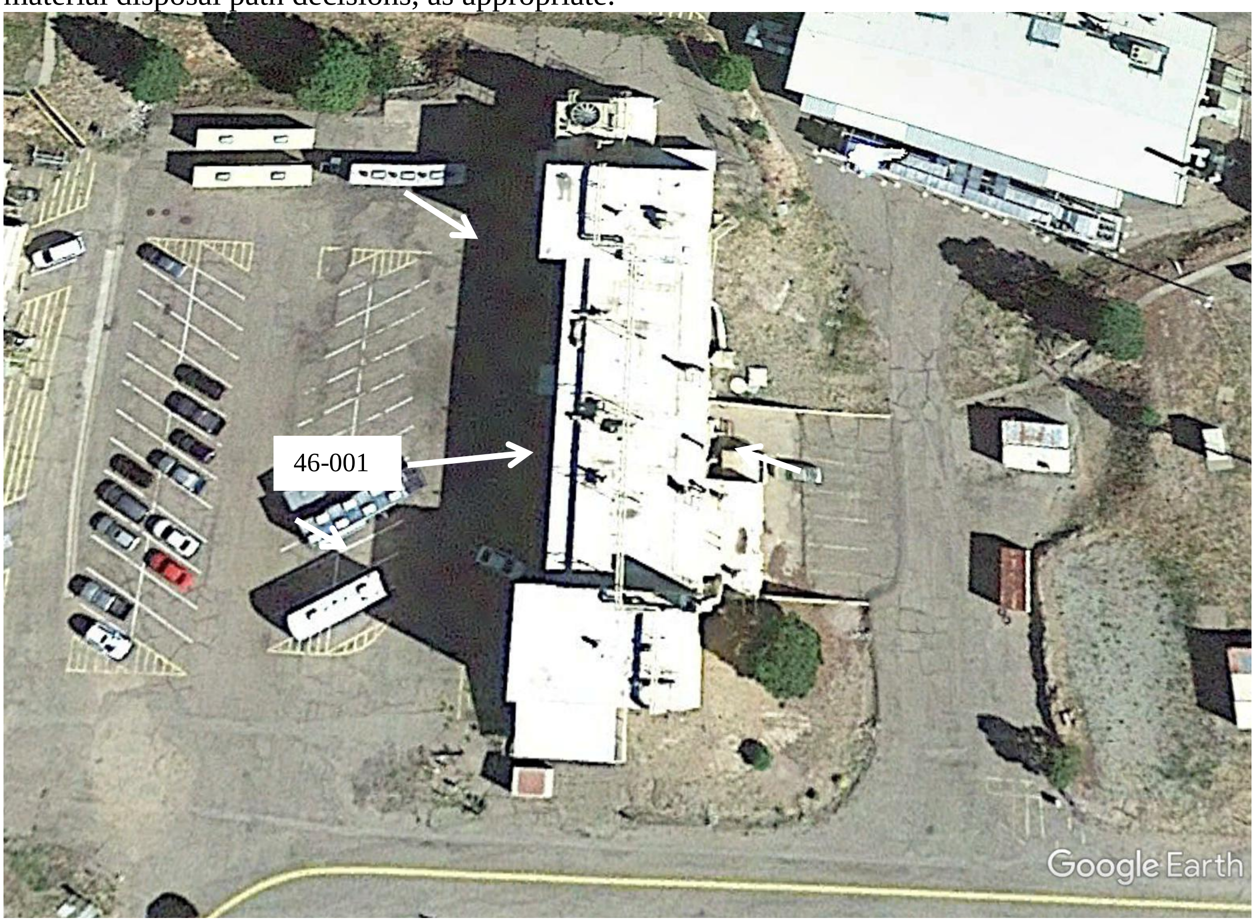


Figure 1. Overhead view of 46-001 slated for D&D.

1.1. Per MARSSIM Section 2.4, there are six principal steps in the MARSSIM Radiation Survey and Site Investigation Process:

- Site Identification
- Historical Site Assessment (HSA)
- Scoping Survey
- Characterization Survey
- Remedial Action Support Survey
- Final Status Survey

1.2. All six of these principal steps could be used in the D&D process for TA-46, building 1. The first two principal steps (i.e., site identification and HSA) have already been completed and the results are detailed in this document. The purpose of this Plan is to satisfy the 3rd and 4th principal steps (scoping and characterization) to assess for radiological impact in these structures, and, if impacted, to characterize the potential contamination. While this plan is for providing scoping data, the rigor of the sampling is designed to meet the quality objectives of a characterization survey.

1.3. The MARSSIM HSA information for these structures is contained is Section 2 below. Prior operational, surveillance, and maintenance information suggests these buildings do not contain radiological contamination. The MARSSIM surveys will be used to assess for the possibility of residual contamination. The survey results will be evaluated for radioactive contamination against MARSAME release requirements, and if release requirements are met, the debris from the buildings are candidates for unrestricted release under DOE Order 458.1.

1.4. If surveys measure radioactive contamination, per MARSSIM Chapter 2, Section 2.4.4., "If an area could be classified as Class 1 or Class 2 for the final status survey, based on the HSA and scoping survey results, a characterization survey is warranted. This type of survey is a detailed radiological environmental characterization of the area." Based on the HSA of the TA-46 structures, Class 1 and/or Class 2 final status survey units are unlikely. While the less rigorous elements of a scoping survey may be sufficient in most decision units in this Plan, a characterization survey structure was used as described in sections 1.5 through 1.8:

1.5. Per MARSSIM Chapter 2, Section 2.4.4., the primary objectives of a characterization survey are to:

- Determine the nature and extent of the contamination.
- Collect data to support evaluation of remedial alternatives and technologies.
- Evaluate whether the survey plan can be optimized for use in the final status survey.
- Provide input to the final status survey design.

1.6. Per MARSSIM Chapter 2, Section 2.4.4., "The characterization survey is the most comprehensive of all the survey types and generates the most data. This includes preparing a reference grid, systematic as well as judgment measurements, and surveys of different media (*e.g.*, surface soils, interior and exterior surfaces of buildings). The decision as to which media will be surveyed is a site-specific decision addressed throughout the Radiation Survey and Site Investigation Process."

1.7. Once the scoping/characterization survey has been completed per this Plan, the data will be analyzed using the MARSAME statistical methods. The MARSAME statistical method results will be used to plan for the remedial action support surveys and/or final status surveys, as appropriate.

1.8. Notes and Assumptions:

1.8.1. This Scoping/Characterization Plan was prepared in accordance with EPC-ES-FSD-004, Environmental Radiation Protection, and developed using EPC-ES-FSD-004 Data Quality Objectives.

1.8.2. The results of this survey are to be used for D&D planning purposes. Per MARSSIM Section 2.4.6, "data from other surveys conducted during the Radiation Survey and Site Investigation Process – such as scoping, characterization, and remedial action support surveys – can provide valuable information for planning a final status survey provided they are of sufficient quality." Release of building materials is contingent upon clean surfaces passing a final status survey, as appropriate.

1.8.3. The nominal release criteria for this D&D project are from Table 10-2 of EPC-ES-FSD-004 for surface contamination (see Section 4 of this Plan). Further restrictions may be imposed by the Waste Management Coordinator.

1.8.4. Waste disposition pathways for material from D&D projects are as follows:

1.8.4.1. Contaminated material that is known or suspected to exceed regulatory limits is to be disposed of as Low Level Waste (LLW).

1.8.4.2. Radiologically encumbered metal items (items within areas posted as radiological areas) fall under the metals moratorium and may not be released.

1.8.4.3. Unencumbered metals may be released for *reuse* within the DOE complex using the Table 10-2 criteria pending an ALARA evaluation.

1.8.4.4. Unencumbered metals may be released to the public for *recycle* or *disposal* using indistinguishable from background criteria.

1.8.4.5. Clean concrete may be released for recycle using the Table 10-2 criteria pending an ALARA evaluation.

1.8.4.6. Other D&D debris may be released to landfill under NMED regulations using indistinguishable from background criteria.

2. **Historical Site Assessment Information**[3]

2.1. TA-46-1, the first building constructed at TA-46 in 1955, was intended to support weapons assembly operations, but was never used for that purpose. The main building housed office spaces and laboratories where various experiments for Project Rover were conducted (see floor plans in Figure 2a,

[3] Text from McGehee E, Garcia K. An assessment of Cold War-Era buildings at Technical Area 46, Los Alamos National Laboratory. Los Alamos National Laboratory report LA-UR-25029; 2014.

b, c). Following the termination of Project Rover, the main building was cleaned out as part of a general cleanout project at the Technical Area. The ducts and drains of this building continue to be listed as moderately contaminated with uranium. At the time of this survey none of the rooms were posted as radiological control areas. There was one capped ventilation duct that had a radioactive material sticker on it.

Given this history, it was our judgement that there was sufficient justification to classify Building 46-001 as a Class 3 (minimal potential for contamination) under MARSAME Guidance. Certain portions of the ventilation duct will be dispositioned as LLW.

3. Survey Units and Data Analysis

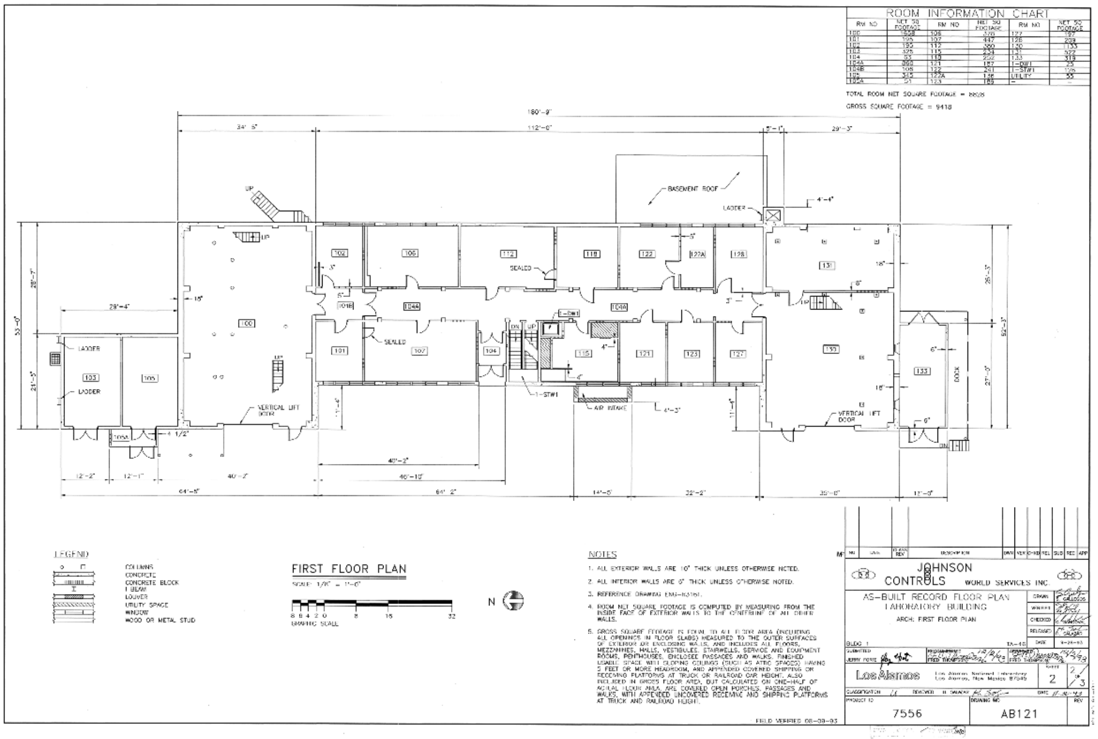
3.1. This Characterization Plan is designed to provide sufficient information for D&D planning and execution. If surveyors encounter contamination or unexplained increases in standard deviation or measured concentrations, further mitigation, sampling, and data analysis may be required.

3.2. Building and room maps are to be used as rough estimates of the spatial layout of the buildings. Adjustments to the survey units and/or maps may be required based on building specifics for this characterization survey and any additional surveys.

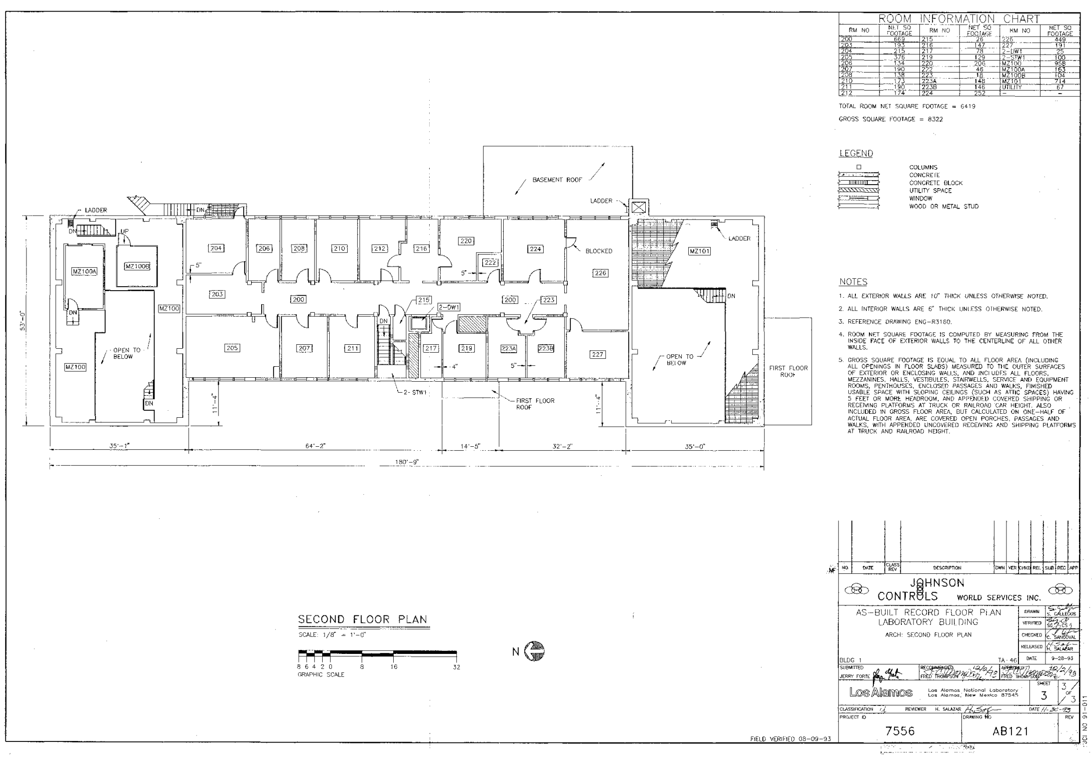
To better manage and coordinate the survey process and data, survey units will be assigned as specified in Section 9. Based on the survey results, the survey units specified in Section 9.1 may be adequate for analysis for release. Alternatively, final status survey units may need to be revised or re-developed.

Figure 2 (a-c). Room layout of building 46-001.

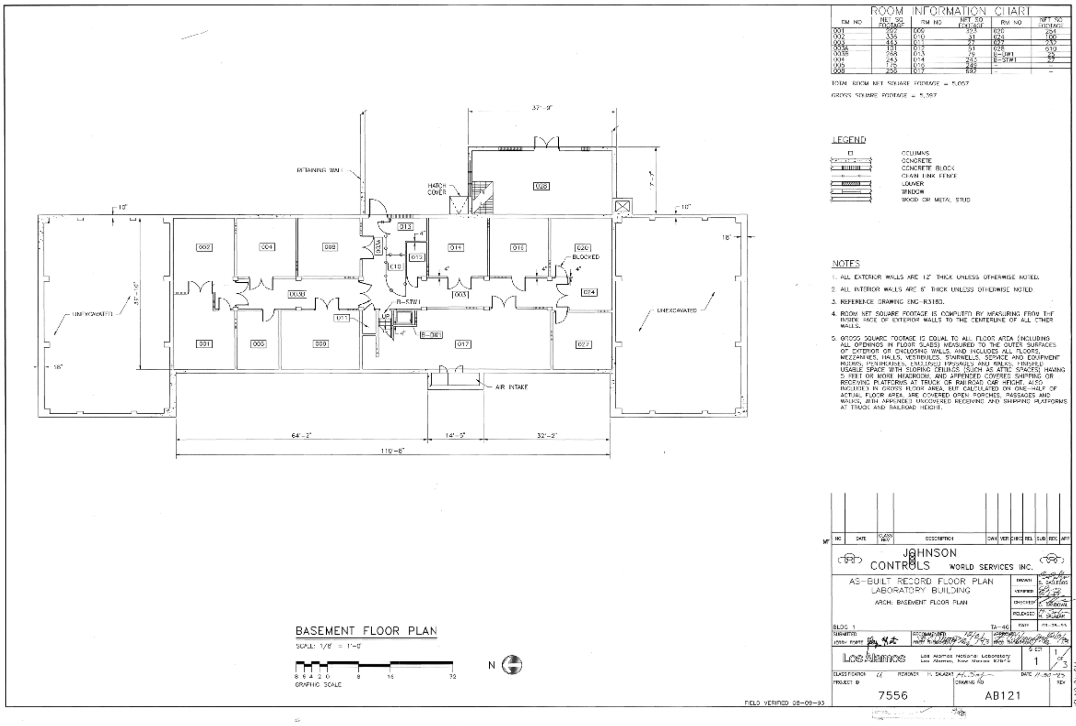
(a) First floor footprint.



(b) Second floor footprint



(c) Footprint for basement



4. Nominal Release Criteria

4.1. Characterization data obtained from this survey may be used to supplement the MARSSIM final status survey if the data meets final status survey Data Quality Objectives. MARSSIM Sections 2.3, 2.4.6, 2.6, 5.1, 5.2.4, 5.3.3.1 discusses the use of characterization surveys (and other MARSSIM surveys) to supplement and augment the final status survey requirements.

4.2. In some cases, additional surveys or sampling may be required to meet all final status survey requirements (e.g., QA measurements).

4.3. Table 1. Nominal release criteria for surface contamination.

Table 1: Values from EPC-ES-FSD-004 Section 1021 Table 2-2		
U-natural, U-235, U-238 and associated decay products (Removable)	1,000	dpm/100cm^2
U-natural, U-235, U-238 and associated decay products (Total)	5,000	dpm/100cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129 (Removable)	20	dpm/100cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129 (Total)	100	dpm/100cm^2
Th-natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 (Removable)	200	dpm/100cm^2
Th-natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 (Total)	1,000	dpm/100cm^2
β/γ emitters (Removable)	1,000	dpm/100cm^2
β/γ emitters (Total)	5,000	dpm/100cm^2
Tritium and Special Tritium Compounds	10,000	dpm/100cm^2

4.3 Sampling and data analysis for volumetric contamination is not required based on the history and potential for activation of building materials.

5. General Survey Instructions

5.1 Verify characterization activities are on the applicable Plan-of-the-Day, as appropriate.

5.2 Perform a Pre-Evaluation Brief and/or Job Task Brief in accordance with P300.

5.3 Verify personnel have appropriate training for the tasks they will be performing.

5.4 Comply with applicable Radiological Work Permit (RWP) requirements, if RWP is required.

5.5 Follow applicable IWD(s), as necessary.

6. Survey-Specific Instructions

6.1 Follow P121, RP-1-DP-37 "Surveying for Fixed and Removable Contamination", and other applicable characterization and sampling procedures. Document all survey results on the appropriate survey form(s) and the survey map(s). All direct and removable measurement results are to be reported as dpm/100cm^2. Do not use "NDA."

6.2 The number of direct and removable measurements is specified in the following survey unit and survey requirement tables for each survey unit. Survey point locations (both direct counts and smears) will be a combination of "uniformly distributed" and "biased" locations determined by the surveyors. Uniformly distributed points shall be spread across all survey unit surfaces in a uniform, even, systematic pattern (similar to a grid pattern). Survey point locations may be changed based on accessibility issues via consultation with the Project Manager and the Environmental Stewardship staff responsible for compliance with DOE Order 458.1.

6.3 Collect and record direct measurement instrument background readings periodically during surveys (approximately 5 background measurements per survey unit). Identify and document background measurements on the survey form and maps with the survey unit number, "-BKG," and sequential background number (e.g. 1-BKG1, 1-BKG2, etc.). Collect background measurements on direct reading probes by pointing the probe into the air and away from any nearby surfaces.

6.4 Required Characterization Surveys include:

6.4.1 Surface scan surveys using a RadEye and 43-93 (α / β) detector, listening for increased count rate areas.

6.4.2 60 second scalar direct surveys using a RadEye and 43-93 (α / β) detector.

6.4.3 Smears (counted for α and β/γ).

6.5 QA survey measurements are not required for MARSSIM scoping or characterization surveys.

6.6 Scan percentages are specified in the survey unit and survey requirement tables for each survey unit (Section 9). For any areas of noticeably elevated count rate, a biased measurement (direct and smear) shall be collected and documented. When biased surveying is required, scan surveys should be used to decide locations of biased survey points, or the biased locations can be selected based on process knowledge. Denote biased surveys sequentially after the last systematic survey location. Biased measurement locations may include: high traffic areas such as room entrances, HVAC intakes and exhaust ducts, storage areas, areas of frequent personnel contact such as doors and door frames, horizontal surfaces such as lab counter tops and shelves, sinks, the openings to sink and floor drains; the tops of lights, beams, crane rails, structural beams, etc.

6.7 On the survey forms, denote surface material (e.g., "concrete," "metal," etc.), as well as locations of biased surveys.

6.8 Use provided survey maps, or create scaled maps as necessary, to document the survey locations and results.

6.9 Smear survey results are to be reported in the form consistent with the results from HPAL. HPAL should be requested to report results as dpm/100cm^2 (not NDA). In consultation with HPAL, isotopic analysis can be performed on smears with high gross alpha/beta results if the radioisotope (or mixture) is unknown. Save all smears for possible future HPAL analysis.

6.10 Collect and maintain all characterization paperwork. Number each page of the survey unit packages using the format "XX of XX". Survey Unit packages should include survey forms, maps, HPAL smear results, and HPAL isotopic analysis (if required). Provide all completed paperwork to the Project Manager and the Environmental Stewardship staff.

7. Surface Labeling Requirements

7.1 Denote survey unit location numbers on structure surfaces where measurements are obtained. Mark locations on using the survey unit designation plus the next sequential survey point location number. For example, for survey unit 46-088 room 102, location survey point number 5, mark the structure surface with the number 46-088-102-5.

7.2 The direct reading probe outline shall be drawn on the surface with a marker and a template to identify the exact surveyed location in the event a re-survey is necessary.

7.3 Denote on the survey map where the scan, direct, and smear surveys were performed. Scan area may be approximated by a highlighted/circled area in survey units that require less than 100% scanning. Record the general scan findings on the survey forms and/or maps.

8.0 Special Support and Safety Requirements

8.1 Upper walls and ceilings/roofs require access via ladders, scaffolding, man-lifts, etc.

8.2 Survey technicians shall be trained for elevated work.

8.3 Pest control may be required in and around all structures.

9.0 Sampling and Analysis Plans for Characterization Surveys

9.1 The following table outlines the requirements for the characterization surveys in the TA-46 Building 001. Include 10% side-by-side measurements for QA. Gamma and neutron measurements are not required.

Building	Smear surveys	Direct (α, β)	Scan (α, β)
46-001 (First Floor)	Rooms 100-128: 25 quasi-systematic grid per room (5 each wall and 5 on floor) plus 10 bias locations.	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2-3 locations	< 5% surface area, biased locations
	Bays 100 and 130-131: 25 quasi-systematic grid per wall and floor plus 20 bias locations (mezzanines included)	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2-3 locations	< 5% surface area, biased locations
46-001 (Second Floor)	Rooms 200-227: 25 quasi-systematic grid per room (5 each wall and 5 on floor) plus 10 bias locations.	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2-3 locations	< 5% surface area, biased locations
46-001 (Basement)	Rooms 001-028: 25 quasi-systematic grid per room (5 each wall and 5 on floor) plus 10 bias locations.	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2-3 locations	< 5% surface area, biased locations

APPENDIX A

Supplement to TA-46 D&D MARSSIM Characterization Survey Plan Structures: TA 46- MARSSIM Statistical Analysis – Output from VSP

Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (e.g., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated number of samples	9
Number of samples adjusted for Elevated Measurement Comparison (EMC)	9
Number of samples with MARSSIM Overage	11

Primary Sampling Objective

The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median (mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median (mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach

A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

VSP offers many options to determine the locations at which measurements are made or samples are collected and subsequently measured. For this design, systematic grid point sampling was chosen. Locating the sample points systematically provides data that are all equidistant apart. This approach does not provide as much information about the spatial structure of the potential contamination as simple random sampling does. Knowledge of the spatial structure is useful for geostatistical analysis. However, it ensures that all portions of the site are equally represented. Statistical analyses of systematically collected data are valid if a random start to the grid is used.

Nuclides/ Radioactivity Limits

The following table summarizes the analyzed nuclides and parameters used for calculating number of samples needed.

Nuclides Analyzed by Study			Parameters for VSP Input		
Nuclide	**DCGL$_W$** *dpm/100cm2*		**UBGR**	**LBGR**	**Standard Deviation Used**
Removable Alpha	20		AL-Removable α	Zero	MDA HPALα (6 dpm)
Removable Beta	1000		AL- Removable β	Zero	MDA HPALβ (11 dpm)
Total Alpha	100		AL-Total α	Median Ref. α	Mean STD of Room α
Total Beta	5000		AL-Total β	Median Ref. β	Mean STD of Room β
IFB Alpha	213		Mean+2 STD Ref α	Median Ref. α	Mean STD of Room α
IFB Beta	2282		Mean+2 STD Ref β	Median Ref. β	Mean STD of Room β

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on a Sign test (see PNNL-13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{S_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty, z)$ (see PNNL-13450 for details),

n is the number of samples,

S_{total} is the estimated standard deviation of the measured values including analytical error,

Δ is the width of the gray region,

α is the acceptable probability of incorrectly concluding the site median (mean) is less than the threshold,

β is the acceptable probability of incorrectly concluding the site median (mean) exceeds the threshold,

$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,

$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

For each nuclide in the **Nuclides Analyzed by Study** table, the values of these inputs that result in the calculated number of sampling locations are:

Nuclide	**n**[a]	**n**[b]	**n**[c]	**Parameter**					
				S	Δ	α	β	$Z_{1-\alpha}$ [d]	$Z_{1-\beta}$ [e]
Removable Alpha	9	9	11	3	20	0.05	0.1	1.64485	1.28155
Removable Beta	9	9	11	6	1000	0.05	0.1	1.64485	1.28155
Total Alpha	9	9	11	9	71	0.05	0.1	1.64485	1.28155
Total Beta	9	9	11	279	3637	0.05	0.1	1.64485	1.28155
IFB Alpha	9	9	11	9	184	0.05	0.1	1.64485	1.28155
IFB Beta	9	9	11	279	919	0.05	0.1	1.64485	1.28155

[a] The number of samples calculated by the formula.
[b] The number of samples increased by EMC calculations.
[c] The final number of samples increased by the MARSSIM Overage of 20%.
[d] This value is automatically calculated by VSP based upon the user defined value of α.
[e] This value is automatically calculated by VSP based upon the user defined value of β.

Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

The first three assumptions will be assessed in a post-data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=213		α=5		α=10		α=15	
		s=558	s=279	s=558	s=279	s=558	s=279
LBGR=90	β=5	130	39	102	30	87	26
	β=10	102	30	80	24	65	20
	β=15	87	26	65	20	52	16
LBGR=80	β=5	39	17	30	14	26	11
	β=10	30	14	24	11	20	9
	β=15	26	11	20	9	16	8
LBGR=70	β=5	22	15	18	11	15	10
	β=10	18	11	14	9	11	8
	β=15	15	10	11	8	10	6

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Note: Values in table are not adjusted for EMC.

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